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S. I. CORY

GROUND POTENTIAL NEUTRALIZING SYSTEM

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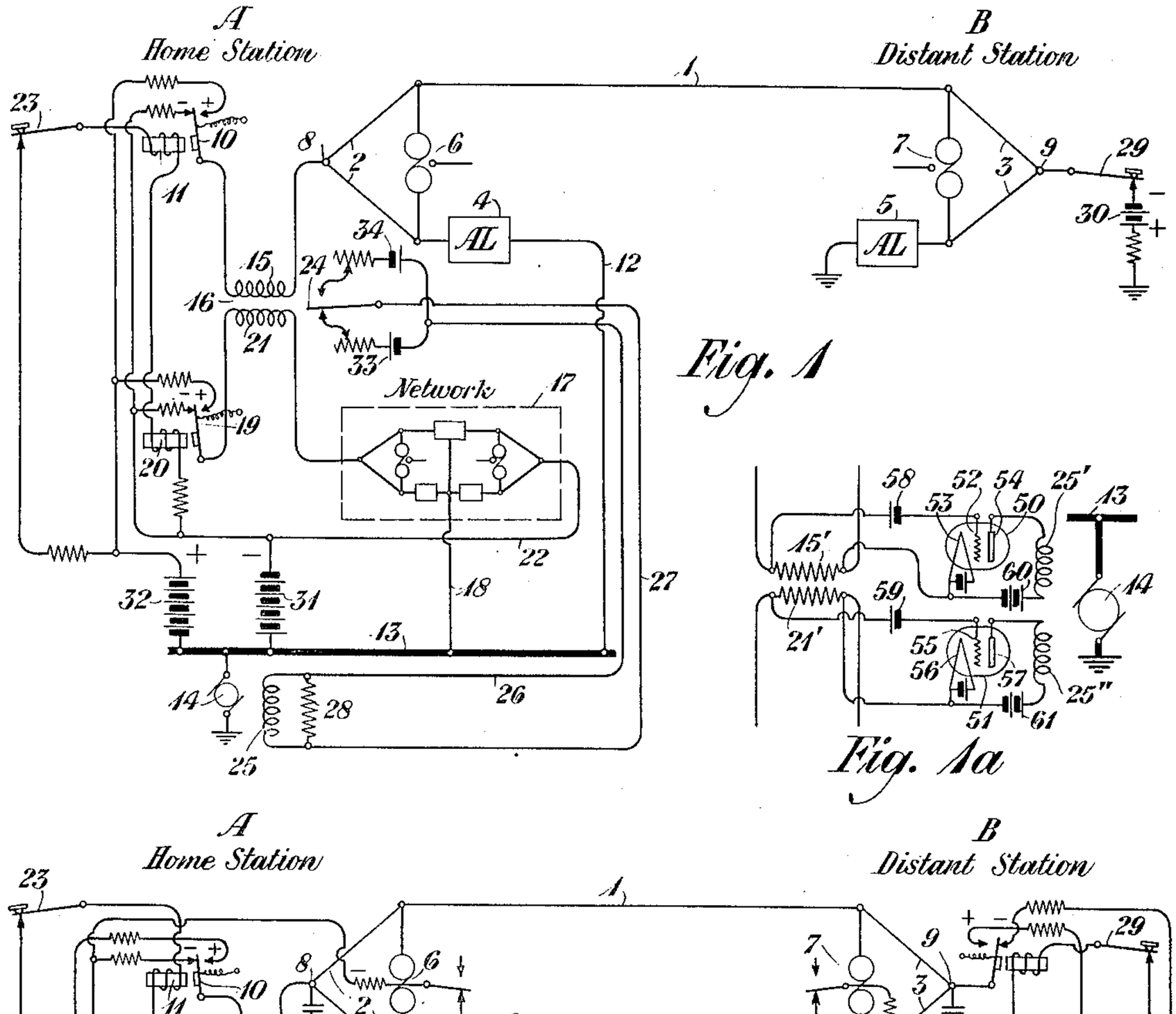

Fig. 1

Fig. 1a

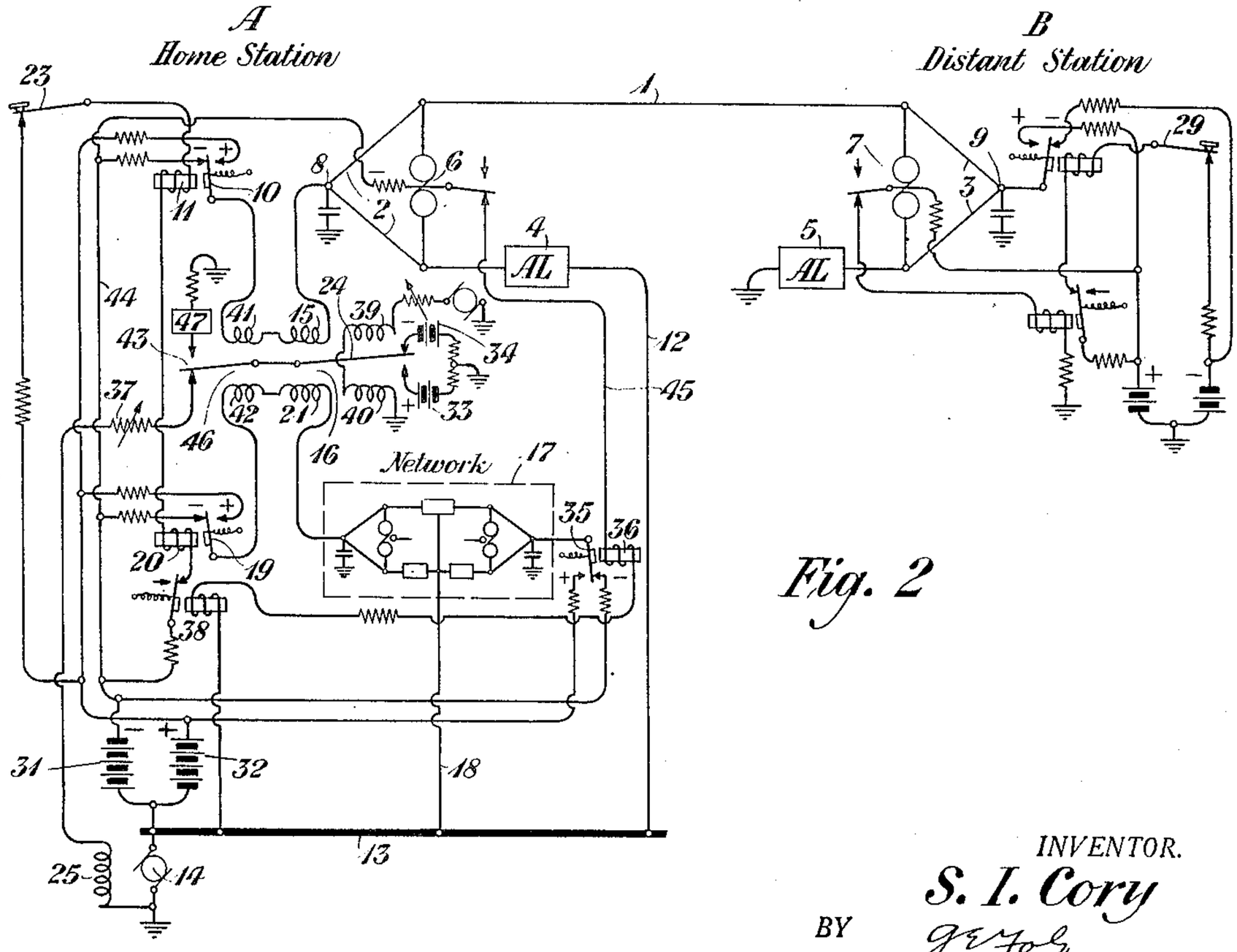

Fig. 2

INVENTOR.
S. I. Cory
BY
ATTORNEY

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UNITED STATES PATENT OFFICE

SAMUEL I. CORY, OF ELMHURST, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

GROUND-POTENTIAL-NEUTRALIZING SYSTEM.

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To all whom it may concern:

Be it known that I, SAMUEL I. CORY, a citizen of the United States, residing at Elmhurst, in the county of Queens and State of New York, have invented certain Improvements in Ground-Potential-Neutralizing Systems, of which the following is a specification.

This invention relates to ground potential controlling systems, and especially to an arrangement to nullify the effect of a difference of ground potential between two points of a grounded signaling circuit without using a pilot wire between the said points.

As is well known to those familiar with the art, a difference in ground potential between two stations on a grounded telegraph circuit establishes a current in the said circuit which interferes with the satisfactory operation of the signaling apparatus. If this potential difference were of a constant value, the relays of the telegraph system could be biased to nullify its effects. On the contrary, these potentials are quite variable and frequently change their sign. This rate of change is dependent on local conditions and is, in general, much slower than the speed of signaling.

Since potential differences of the order of 30 to 50 volts have been found in some localities, it is, of course, obvious that means must be employed to nullify the effect of the resultant interfering currents if satisfactory operation of the circuits is to be attained. If these earth currents can be substantially eliminated, it is possible to use smaller potentials and currents in grounded telegraph systems, to improve the duplex balance, and to obtain twice as many telegraph circuits as are now obtained in small gauge cables.

Various means have been devised to eliminate the effect of ground potential differences in signaling circuits, especially in grounded telegraph circuits, but in all such systems known to me, it is necessary to use a pilot wire between stations or to some point of zero potential. The use of a circuit for this special purpose is not only expensive but is unsatisfactory for other reasons.

It is the object of this invention to provide a method of and means for nullifying the effect upon the signaling apparatus of a grounded signaling circuit due to a difference of ground potential between two points upon the said circuit, which method and means do not require the use of a special circuit or pilot wire connecting the two grounded points. This system will be better understood from the following description, when read in connection with the attached drawing, of which Figure 1 shows the embodiment of the invention in a telegraph circuit adapted for one-way operation, Fig. 1ª shows a modification of the controlling mechanism, and Fig. 2 shows the invention embodied in a complete bridge polar duplex telegraph circuit.

In Fig. 1, a line circuit or line 1 extends between two stations A and B, the former of which is designated the home station and the latter the distant station. This line is connected at station A with one of the bridge arms 2, with which is also connected an artificial line 4, designed and arranged to balance the line 1, which artificial line is connected by the conductor 12 to the common bus-bar 13, which is grounded through the generator 14. Bridged across the outer ends of the said arms is a receiving relay 6. The apex 8 of the said arms is connected with the armature 10 of the pole changer 11, the said connection including one of the windings 15 of the control relay 16, which will be more fully described hereinafter. The network 17 is designed and arranged to simulate electrically the line 1 and its associated terminal apparatus at stations A and B. A preferred form of the network 17 would contain various component parts, each of which would resemble electrically a part of the grounded telegraph circuit which it is designed to reproduce. The two component parts which represent the artificial lines would be connected by means of the conductor 18 to the grounded bus 13. One end or terminal of the network 17 is connected with the armature 19 of a pole changer 20, the connection including another winding 21 of the control relay 16. The opposite end of the network 17 is connected by conductor 22 with the negative pole of the main line battery. The windings of the pole changers 11 and 20 are connected in series between the negative pole of the main line battery and the positive pole of the said battery, the connection including a key 23, by means of which the said pole changers are operated. The armatures of the pole changers are adapted to move between two contacts, one of which is connected

with the negative and the other with the positive battery. The armature 24 of the control relay 16 is adapted to move between two contacts, the upper of which is connected with a negative and the lower with a positive battery. The opposite poles of these batteries are connected by a common conductor with a field winding 25 of the generator 14. The other side of this main winding is connected by conductor 27 with the armature 24. A resistance 28 may be connected in parallel with the winding 25 in order to minimize sparking at the contacts between which the armature 24 moves.

The apparatus at the distant station B is preferably similar to the apparatus normally connected with the line at the station A. Thus, in the drawing the line 1 is shown connected with the bridge arms 3, having connected thereto the artificial line 5 and a receiving relay 7. The apex 9 of the bridge arms is connected through the key 29 with the negative pole of the battery 30. A pole changer, similar to 11 at station A, has been omitted at B for the purpose of simplicity. When station B is receiving from station A over a one-way circuit, the negative pole of the battery would be connected with the apex 9, as shown in the drawing. The apparatus for nullifying the effect of ground potential difference is required at only one end of the line circuit, as will be apparent from the following description of the method of operation of the circuit.

When the key 23 is closed, current will flow from the negative battery 31, through the windings of the pole changers 20 and 11, through the key 23 to the positive battery 32, thereby energizing the pole changers and moving the armatures 19 and 10, respectively, until they touch the left-hand contacts of the said pole changers which are connected with the negative battery 31. Since the negative battery is connected with the line at station B, no current will flow through the line. Current will flow, however, from the positive side of battery 31, through conductor 12 and artificial line 4, winding 15 of relay 16, thence through the contact of the pole changer 11 to the negative side of battery 31. Since the negative side of battery 31 is connected with what may be termed the distant end of the network 17, current will not flow in the line side of the said network, because of the identity of the polarity at the opposite ends. However, current will flow from the positive side of battery 31, over conductor 18, through the artificial line side of the network 17, winding 21 of relay 16, the negative contact of pole changer 20 to the negative side of battery 31. It will be apparent, therefore, that since current is flowing in the same direction in the windings of the relay 16 and since the windings are thereby opposed, the action of the armature 24 will be unaffected, and consequently, the potential produced by the generator 14, which is connected between the bus-bar 13 and ground, will be unchanged.

When the key 23 is opened, the armatures of the pole changers 11 and 20 will be drawn to the positive contacts of the said pole changers by means of springs, and positive potential will thereby be applied to the line 1 and the network 17. Therefore, current will flow through both of the bridge arms of the terminal circuit connected with the line 1, and also through the bridge arms connected with the network 17. These currents will, of course, flow through the windings 15 and 21 of the relay 16 and the flow will be in the same direction, but, of course, the flow is opposite to that when the armatures of both pole changers were touching the negative contacts. Accordingly, the action of the armature 24 of the relay 16 will be unaffected and no variation will result in the voltage produced by the generator 14. Throughout the foregoing described operation the armature 24 is vibrating freely and at substantially uniform periodicity for the following reason: With the armature on the position shown in the drawing the generator 14 will begin to create a voltage which will, for example, add algebraically to battery voltages. This will create an unbalance between the currents in windings 15 and 21 which will cause the armature to move to its upper contact, thereby reversing the current through the field winding 25. The generator voltage will therefore be reversed in direction and will subtract from the battery voltage. The windings 15 and 21 will again be unbalanced, thereby causing the armature 24 to move to its other contact. This regular swinging of the armature will continue until a circuit condition occurs which results in holding the armature upon either of its contacts for a greater length of time than normal. It will be seen, therefore, that if the signaling currents in windings 15 and 21 of relay 16 are made substantially equal by the proper adjustment of the network 17 and there is no current in winding 15 due to ground potential, the average voltage produced by the generator 14 is zero because the armature 24 vibrates freely between its contacts and remains upon each substantially the same length of time.

When a difference of ground potential exists between station A and station B, current will flow over the line circuit 1 in a direction dependent upon which of the stations is of a higher potential. This difference of ground potential will cause current to flow over a circuit from ground, through the generator 14, the bus-bar 13, through the batteries 31 or 32, the armature of pole changer 11, winding 15 of relay 16, line 1,

battery 30 at station B to ground. It will be seen, therefore, that when a difference of ground potential exists, the currents flowing in the windings 15 and 21 of relay 16 are not equal, so that a resultant flux occurs which moves the armature 24, the direction of the movement depending upon the direction of the resultant flux.

As has been stated, the armature 24 which is always in condition of constant vibration will tend to be held against either of its contacts as the result of the unbalanced currents in the windings 15 and 21. The batteries 33-and 34 are so poled that the direction of the current flow produced by the generator 14 will always be opposite to the direction of the current through the line produced by the difference of ground potential between the two stations so that the effect thereof will be nullified. The direction of the neutralizing current is controlled by the direction of the current through the field winding 25, which, of course, depends upon whether the armature 24 of the control relay 16 is in contact with its upper or lower contact point. The magnitude of the neutralizing current will, of course, be dependent upon the strength of the field current, which in turn may be controlled by the proper adjustment of the resistances connected in series with the batteries 33 and 34. This regulation may be controlled either manually or automatically, and the means for doing this form no part of this invention and are not claimed herein.

It will be seen, therefore, that the arrangement shown in Fig. 1, constitutes one form of embodiment of my invention for neutralizing the effect of a difference of ground potential upon the receiving apparatus connected with the line circuit between two stations.

Another form of controlling mechanism is shown in Fig. 1ª. In this arrangement, the resistances 15′ and 21′ are connected with the real circuit and the artificial circuit in the same manner in which the inductive windings 15 and 21 are connected in Fig. 1. In fact, the inductive windings might be used in the arrangement shown in Fig. 1ª, but I prefer to use resistances in this arrangement. The input side of the vacuum tube device 50 is connected across the resistance 15′, and a similar vacuum tube device 51, having the same operating characteristics and constants as 50, is connected across the resistance 21′. Thus, the input circuit of the tube 50 includes the grid 52, the source of potential 58, the resistance 15′ and the filament 53. Similarly, the input circuit of the tube 51 includes the grid 55, the source of potential 59, the resistance 21′ and the filament 56. The output circuit of the tube 50 comprises the plate 54, the winding 25′, space battery 60, and the filament 53. Similarly, the output circuit of the tube 51 includes the plate 57, the winding 25″, space battery 61, and the filament 56. The windings 25′ and 25″ are so arranged so that no flux will be produced by equal currents therein and therefore, no effect will be produced upon the armature 14 of the generator, which is connected between ground and the bus-bar 13, as shown in Fig. 1. If the currents flowing through the resistances 15′ and 21′ are equal, the differences in potential across these resistances will be equal and consequently the same differences of potential will be established simultaneously between the grid and the filament of each tube. Accordingly, the plate current in each output circuit will vary simultaneously to the same degree and thereby the fluxes produced by the windings 25′ and 25″ will be at all times equal and opposite so that no change of voltage is produced by the generator 14. If, however, the current through the resistance 15′ is greater than that in 21′, due for example to a difference of ground potential between the terminals of line 1, the voltage variations between the grid and the filament of the tube 50 will be greater than that in the tube 51, and consequently the output current of the tube 50 will be different from that of 51. This difference of current will produce a resultant flux which will cause the armature 14 to establish a corresponding difference of potential between the bus-bar 13 and ground.

Other means of controlling the voltage generated by the armature 14 will occur to those who are familiar with the art. Thus, for example, if the currents in the windings 15 and 21 are of sufficient magnitudes the windings might be used directly as the field windings of the armature 14 so that the voltage produced thereby will result from the difference in magnitude and in direction of the currents in the said windings. It is also possible to control the current flowing through the field winding 25 by means of sources of current connected with groups of selenium cells, the resistance of which may be varied by means of a ray of light controlled by a differential galvanometer which may be inserted in the circuit of Fig. 1 at the position occupied by the windings 15 and 21.

The arrangement shown in Fig. 1 is adapted for one-way operation only, since what may be termed the distant end of the network 17 is permanently connected with the negative battery and no means are provided for changing the polarity applied to this terminal, such as would be necessary in order to simulate the condition existing when the key at the distant station B is opened. Fig. 2 shows the application of the invention to a bridged polar duplex telegraph circuit adapted for half duplex operation. In this figure the same designating

numerals have been applied to the parts which perform the same function in both figures. In Fig. 2, the armature of relay 6 is connected with the negative battery 31 and is adapted to close a circuit which includes a neutral relay 36, the armature of which, 35, is connected with one terminal of the network 17. The contact points of the relay 36 are connected with the positive and negative batteries 32 and 31, respectively, so as to apply potentials of those polarities to the distant terminal of the network 17. A relay 38, whose winding is in series with that of relay 36, is designed to close a circuit which includes the windings of the pole changers 11 and 20. The control relay 16 has a plurality of windings connected therewith. The windings 39 and 40 are connected in series with a source of alternating current, to maintain the armature of the relay 16 in a state of vibration at a frequency of, for example, 20 cycles. The windings 15 and 21 of this relay are designed to control the movement of the armature in accordance with the degree of unbalance existing between the currents that traverse these windings. Windings 41 and 42 of the alarm relay 46 are intended to control the armature 43, which opens the circuit of the field winding 25 of the generator 14 and sets in operation an alarm signal 47.

Having in mind the foregoing description of the parts of the circuit in which the invention is embodied, the invention will be clear from the following description of the mode of operation of the circuit.

Let it be assumed that keys 23 and 29 at stations A and B, respectively, are closed, which connects negative sources of potential to the apexes of the line circuit at the two stations, and also applies a negative potential to what may be termed the home end of the network 17. A circuit will also be established from the negative terminal of battery 31, conductor 44, the armature of relay 6, conductor 45, windings of relays 36 and 38 to the opposite pole of battery 31. This will cause the relays 36 and 38 to operate, thereby connecting the distant end of the network 17 with the negative battery 31 through the armature 35. By the operation of relay 38, the circuit of the pole changers 11 and 20 is closed. Current will not flow over the line since equal potentials of the same polarity have been applied to the two terminals thereof, and likewise current will not flow through the branch of the network 17 which corresponds to and simulates the line conductor of the line circuit. Current will flow through the artificial line 4 of the line circuit and also through the corresponding branch of the network 17. Therefore, the currents flowing through windings 41 and 15 will equal that flowing in windings 42 and 21, and their direction will be such as to substantially oppose each other and produce no effect upon the armature 24. Likewise, no effect will be produced upon the armature 43.

If the key at the distant station B is maintained closed so as to keep the negative source of potential connected to the said distant end of the line circuit, and key 23 is opened, the pole changers 11 and 20 will operate, so as to connect the positive source of potential to both the line circuit and to the network 17. Since the relay 6 is balanced by the bridge arms against currents transmitted from the home station, the armature of the said relay will maintain the circuit through the windings of relays 36 and 38 in closed condition, which will keep the negative source of potential connected to the distant end of the network 17. The control relay 16 will not be affected, and consequently, the potential produced by the direct current generator 14 will be unchanged.

If the key 29 at station B is opened during the course of sending signals from station A, in order that the operator at station B may get control of the circuit, it is desirable that the conditions at the distant end of the network 17 will simulate the changes which are taking place at the distant station B of the line circuit. Let it be assumed that key 29 is opened while key 23 is closed,—that is to say,—the positive source of potential will be connected to the line circuit at B, while the negative source of potential is connected with the line circuit and also with the home end of the network at station A. It is desirable, therefore, that the distant end of the network 17 shall be connected with the positive source of potential. This is effected in the following manner: When the distant station connects its positive battery to the line, current will flow over the line circuit and operate relay 6. By the operation of this relay, the circuit through its lower contact will be opened, thereby releasing both the neutral relay 36 and also relay 38. When relay 36 is released, its armature 35 will be drawn back and connect the positive source of potential to the distant end of the net work 17, thereby simulating the condition that exists at the distant station B of the line circuit. By releasing relay 38, the circuit through the windings of the pole changers 11 and 20 is opened, but the armatures 10 and 19 will be held to the negative contacts by means of a holding circuit which is connected with modern pole changers in a manner well established in the art. The current flow through the windings of the control relay 16 will, therefore, be of the same magnitude and in such direction as to neutralize their effects upon the armatures 24 and 43.

If, however, a difference of ground poten-

tial exists between the grounding points at stations A and B, current will flow through the line circuit and through windings 15 and 41 of the relays 16 and 46, respectively, the direction and magnitude of which will, of course, be dependent upon the ground potential. This current will produce an unbalanced condition in both of said relays. The effect in relay 16 causes the armature 24 to remain upon one of the contacts connected with the sources of potential 33 and 34 a longer time than upon the other contact, which controls the magnitude and direction of the potential set up by the direct current generator 14 to nullify the effects of the said ground potential. Relay 46 is adjusted so that its armature 43 will remain upon its lower contact so as to keep the circuit closed through the field winding of the generator 14 regardless of variations in ground potential. It is adjusted to open its lower contact and to close its upper contact in case the line circuit 1 is opened or if trouble exists in the balancing circuit, or in the control relay 16. This operates the alarm signal 47 which apprises the attendants that the line circuit 1 is open. This feature is important because the single generator 14 neutralizes the ground potential on all line circuits between A and B. Since this generator is controlled by currents over line circuit 1, it is essential that any trouble on this particular line circuit shall be promptly made known.

The arrangement shown for neutralizing the difference in ground potential operates as follows: the armature 24 of relay 16 not only tends to vibrate continuously in the manner described under Fig. 1, but is assisted by means of an alternating current of suitable frequency, say in the order of approximately 20 cycles transmitted through the windings 39 and 40. If the current in winding 15 exactly equals that of winding 21, which condition exists when the line current exactly equals the network current and when no current due to difference of ground potential is flowing through the said line circuit, the armature 24 of the relay 16 will stay on the positive and negative contacts an equal amount of time, and the generator 14, the armature of which is connected in the ground lead, will not introduce more potential to ground in one direction than in the other direction. If an unbalanced current exists in the windings 15 and 21 due to a difference of ground potential, the armature will stay on one contact longer than on the other, so that if the generator is properly poled, a voltage will be introduced in the ground lead that will oppose exactly the difference of potential through the ground. When this condition is attained, no currents will flow through the windings 15 and 41 except signaling currents.

The adjustment of the apparatus required to nullify the effect of ground potentials is no different from that necessary for ordinary telegraph operation. The voltages of the telegraph battery at the station where the apparatus is used should be held fairly constant. If they are nearly constant, the apparatus will correct for unbalance in battery voltages at the distant end. In applying this system, it is to be noted that one neutralizer set applied to a working wire between two stations will take care of the difference of ground potential upon all the wires between the two stations. Likewise, a working wire to a reference point of zero potential can be used to carry out this method, in which case all circuits from one office may be protected by one neutralizer equipment.

Furthermore, the invention is not limited to the forms shown in the drawing or described in the specification, which relate to automatic means for controlling the generator voltage but includes any means for controlling the generator voltage in an electrical transmission system comprising a real line and an artificial line designed to balance the real line.

It will be seen that this invention provides simple and effective means for nullifying the effect of a difference of ground potential upon the signaling apparatus connected with grounded telegraph circuits, and is applicable to all types of circuits and conditions of operation.

Although this invention has been disclosed as embodied in a particular form and arrangement of parts, it is to be understood that it is capable of embodiment in other forms and arrangements without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a grounded telegraph system, the combination with telegraph stations and a telegraph line uniting the same, of a ground connection for said line at each station, an artificial network simulating electrically said line and said stations, and means associated with and controlled by a difference of currents in said line and said network for neutralizing differences in ground potential between the said ground connections.

2. In a grounded telegraph system, the combination with a real circuit comprising a line circuit and duplex terminal circuits at each end thereof, of an artificial circuit simulating closely the said real circuit, and means connected with the said real and the said artificial circuits for controlling the ground potential applied between the said line circuit and ground.

3. In a grounded telegraph system, the combination with a real circuit comprising a line circuit and duplex terminal circuits at each end thereof, of an artificial circuit

simulating closely the said real circuit, controlling means connected with the said real and the said artificial circuit, and voltage generating means regulated by the said controlling means for neutralizing a difference of ground potential effective in the said line circuit.

4. In a grounded telegraph system, the combination with a real circuit comprising a line circuit and duplex terminal circuits at each end thereof, of an artificial circuit simulating closely the said real circuit, controlling means connected with the said real and the said artificial circuit and operable by virtue of a difference of current therein, and voltage generating means regulated by the said controlling means for neutralizing a difference of ground potential effective in the said line circuit.

5. In a grounded telegraph system, the combination with a real circuit comprising a line circuit and duplex terminal circuits at each end thereof, an artificial circuit simulating closely the said real circuit, means for applying signaling impulses to the said artificial circuit simultaneously with those applied to the said real circuit, the said impulses being of equal magnitude, controlling means connected with the said real and the said artificial circuits responsive to a difference of currents in the said circuits, and voltage generating means regulated by the said controlling means to neutralize a difference of ground potential in the said line circuit.

6. In a grounded telegraph system, the combination with signaling circuit comprising line circuit grounded at at least two places and terminal circuits connected with the said line circuit, of a network arranged to simulate electrically the said signaling circuit, sources of potential of opposite polarities, a ground connection for said sources having a generator connected therewith, a control relay having a plurality of windings individual to and connected with the said signaling circuit and said network, and having an armature adapted to control the current through the field winding of the said generator, and means to apply impulses of the same polarity and strength from said sources, whereby the said control relay will be actuated only when an interference current due to a difference of ground potential flows through one winding of said control relay.

7. In a telegraph system exposed to interference from a difference in ground potential, the combination with a line circuit having terminal circuits of a network designed to simulate the said line circuit and its terminal circuits, means for simultaneously applying impulses of the same polarity to one of said terminal circuits and to said network, and means to control the potential applied to said line comprising a plural winding relay responsive to a difference in magnitude of the currents in the said line and said network and adapted to control a generator connected with the said impulse applying means whereby the difference in ground potential may be neutralized.

8. In a duplex telegraph system exposed to interference from a difference in ground potential, the combination with a telegraph circuit comprising a line circuit and terminal circuits with receiving relays and artificial lines associated therewith, of a network arranged to simulate said telegraph circuit, pole changers adapted to apply impulses of the same polarity simultaneously to one end of said line circuit and to one end of said network, and a neutral relay controlled by one if said receiving relays to reverse the polarity applied to the other end of said network whenever the polarity at the distant end of said line circuit is changed, thereby maintaining uniformity of the electrical condition of the said line circuit and said network.

9. In a grounded duplex telegraph system exposed to interference from a difference in ground potential, the combination with a line circuit of terminal circuits each comprising bridge arms connected with said line circuit, an artificial line simulating said line circuit and also connected with said bridge arms, and a receiving relay bridged across said bridge arms, a network arranged to simulate the said line circuit and its terminal circuits, a plurality of transmitting pole changers, a control relay having a plurality of windings one of which is connected between one of the said pole changers and one of said terminal circuits, and the other of which is connected between another of said pole changers and said network, and means controlled by unbalanced currents in the windings of said control relay to nullify the effect of the said unbalanced current upon signal-responsive apparatus.

10. In a signaling system comprising a grounded signaling circuit consisting of a line circuit and terminal circuits connected with each end thereof, an artificial circuit simulating the said signaling circuit, and foreign potential neutralizing means connected with the said signaling circuit and the said artificial circuit responsive to currents set up in the said signaling circuit by a foreign potential, but not responsive to signaling currents flowing over the said signaling circuit.

11. In a signaling system comprising a grounded signaling circuit consisting of a line circuit and terminal circuits connected with each end thereof, an artificial circuit simulating the said signaling circuit, means for applying signaling currents to the said signaling circuit and the said artificial cir-

cuit, a relay connected with the said signaling circuit and the said artificial circuit adjusted to be unresponsive to the said signaling currents and responsive to currents resulting from a potential to ground set up in the said signaling circuit by the extraneous sources, and potential generating means controlled by the said relay to neutralize the said difference of ground potential.

In testimony whereof, I have signed my name to this specification this 8th day of March, 1922.

SAMUEL I. CORY.